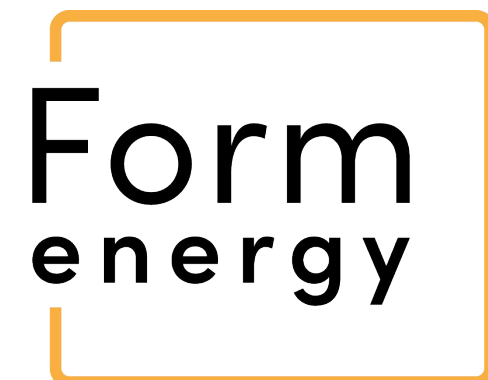


# BREAKTHROUGH LOW-COST, MULTI-DAY ENERGY STORAGE

Illinois Commerce Commission

January 20, 2022

Jason Houck, Sr. Manager, Policy & Reg. Affairs



Energy Storage  
For A Better World

CONFIDENTIAL





# Agenda

- Opportunity for Multi-Day Storage
- Form's Iron-Air Battery
- Multi-Day Storage Applications
- Modeling Best Practices



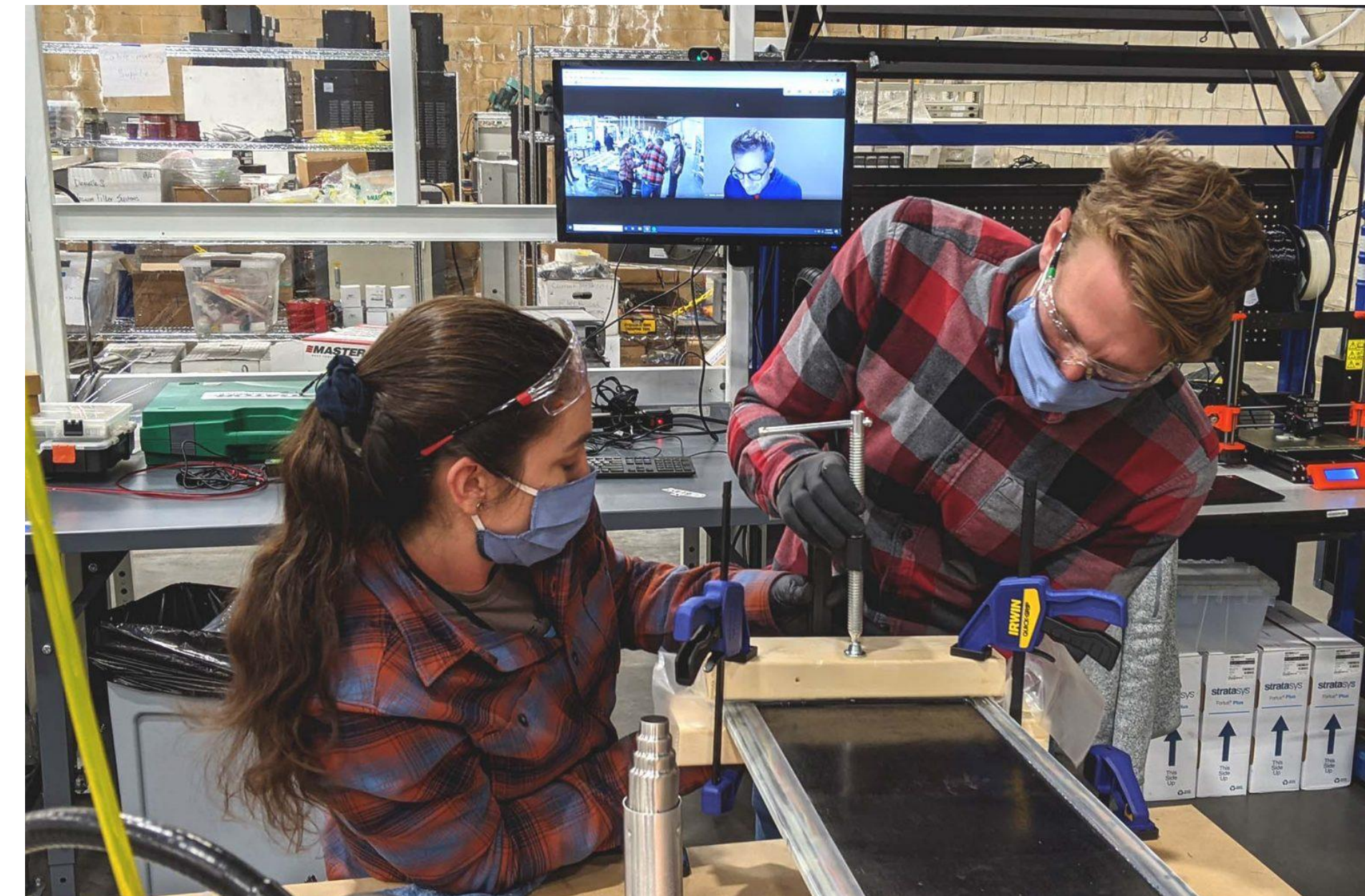
# Our Team

- **Team:**

- 200+ employees across the U.S.
- 50,000 ft<sup>2</sup> facility in Somerville, MA
- 50,000 ft<sup>2</sup> facility in Bay Area, CA
- 15,000 ft<sup>2</sup> facility near Pittsburgh, PA

- **Investors:**

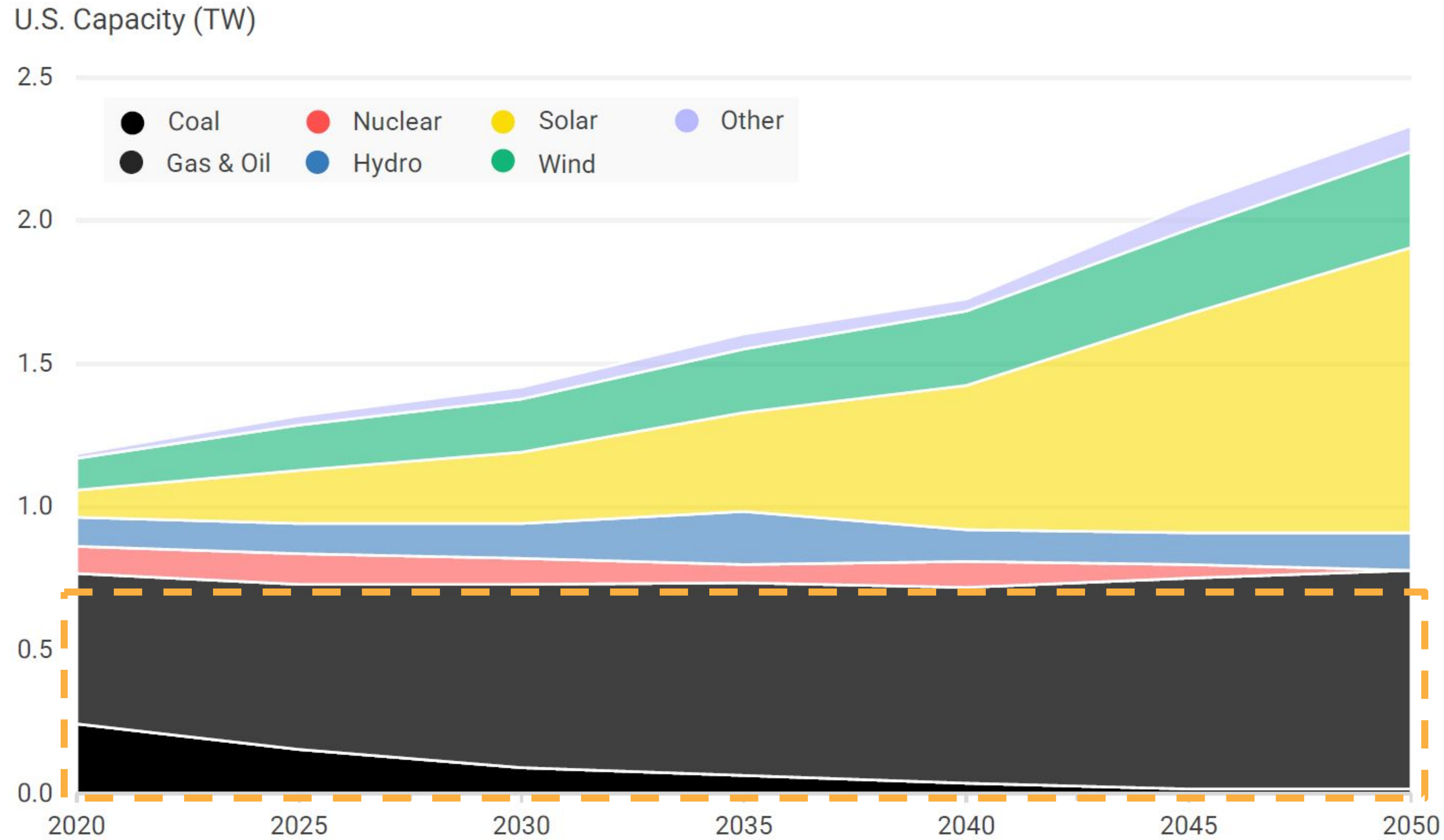
- **\$370M** in venture capital from Breakthrough Energy Ventures (BEV), Coatue Management, NGP Energy Technology Partners III, ArcelorMittal, Temasek, Energy Impact Partners, Prelude Ventures, MIT's The Engine, Capricorn Investment Group, Eni Next, Macquarie Capital and other long-term, impact oriented investors





# The tech gap: 780 GW U.S. opportunity to replace fossil plants

## Forecast US Generation Capacity with Existing Commercial Technologies



Source: BNEF New Energy Outlook 2020

**Change:** As the grid electrifies and renewable costs plummet:

- >3.5x growth in renewables
- 1 additional TW of capacity

**Obstacle:** Legacy fossil remains to maintain reliability as electric demand rises.

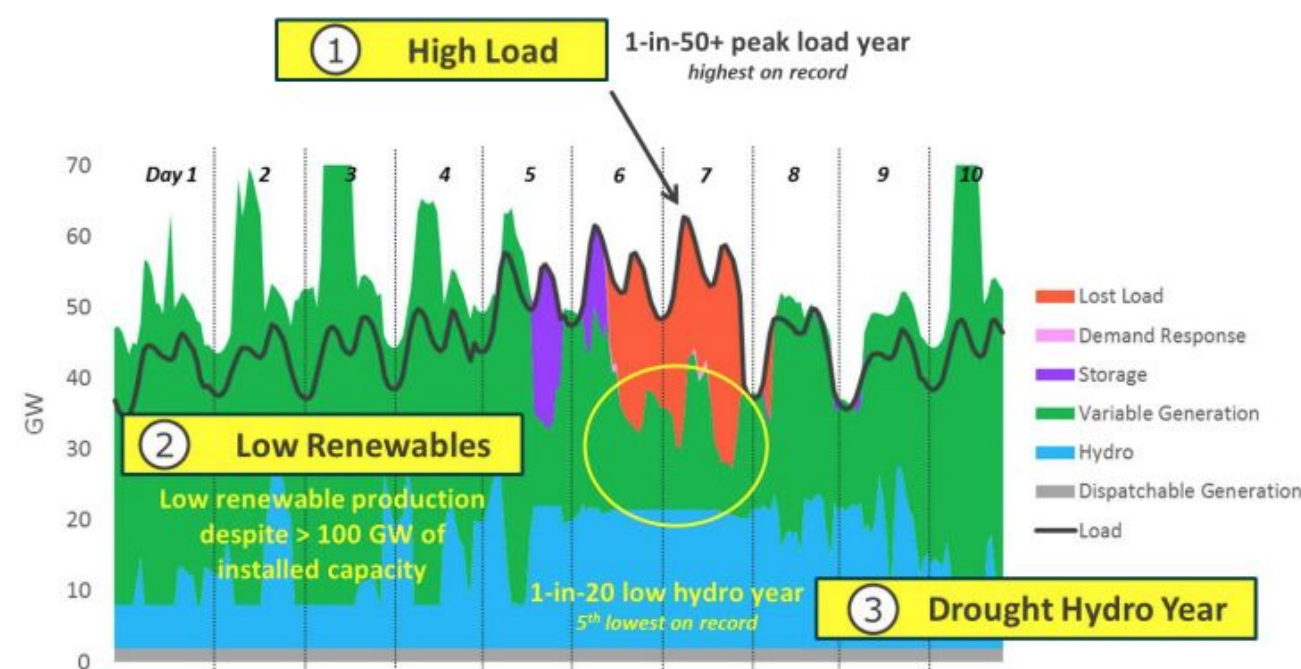
**Opportunity:** Eliminate >780 GW of gas power plants by firming renewable energy



# Weather-driven multi-day reliability challenges are universal

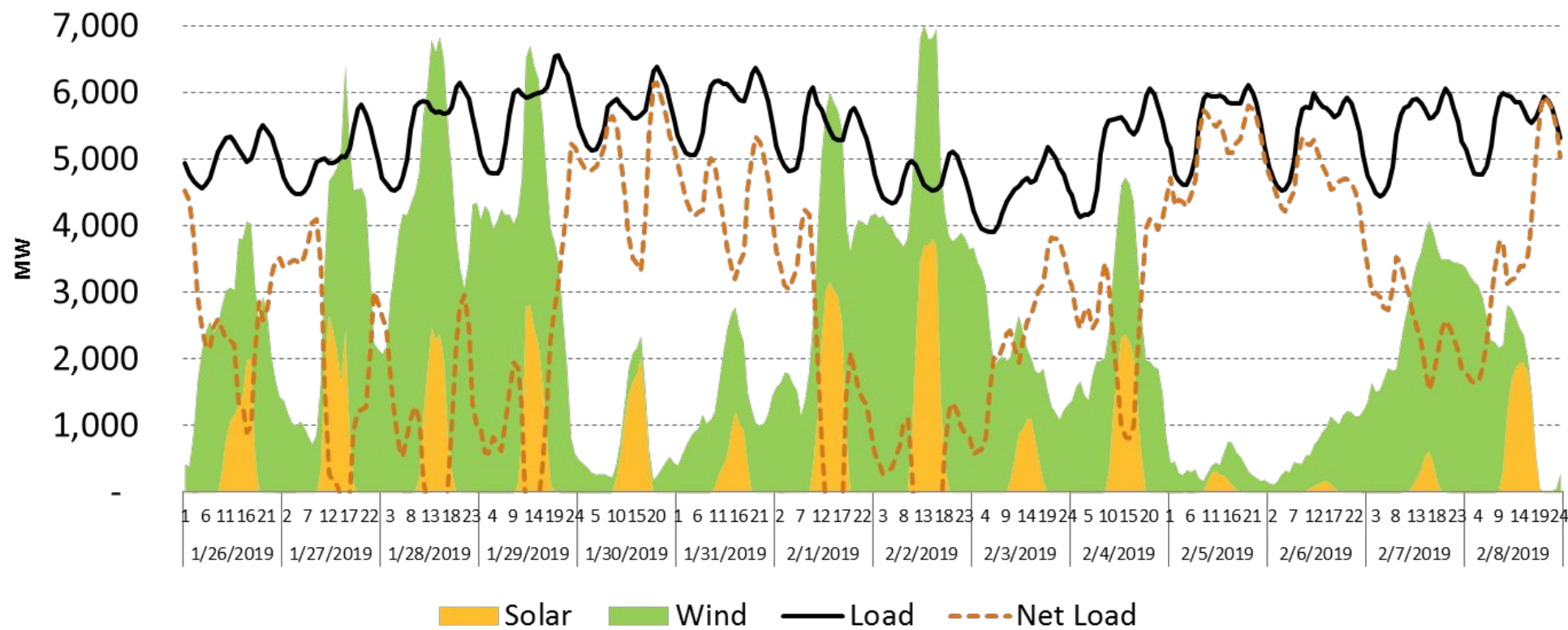
## Pacific Northwest Multi-Day Weather Event, 2050

Figure 20: Loss-of-load Example in a Sample Week



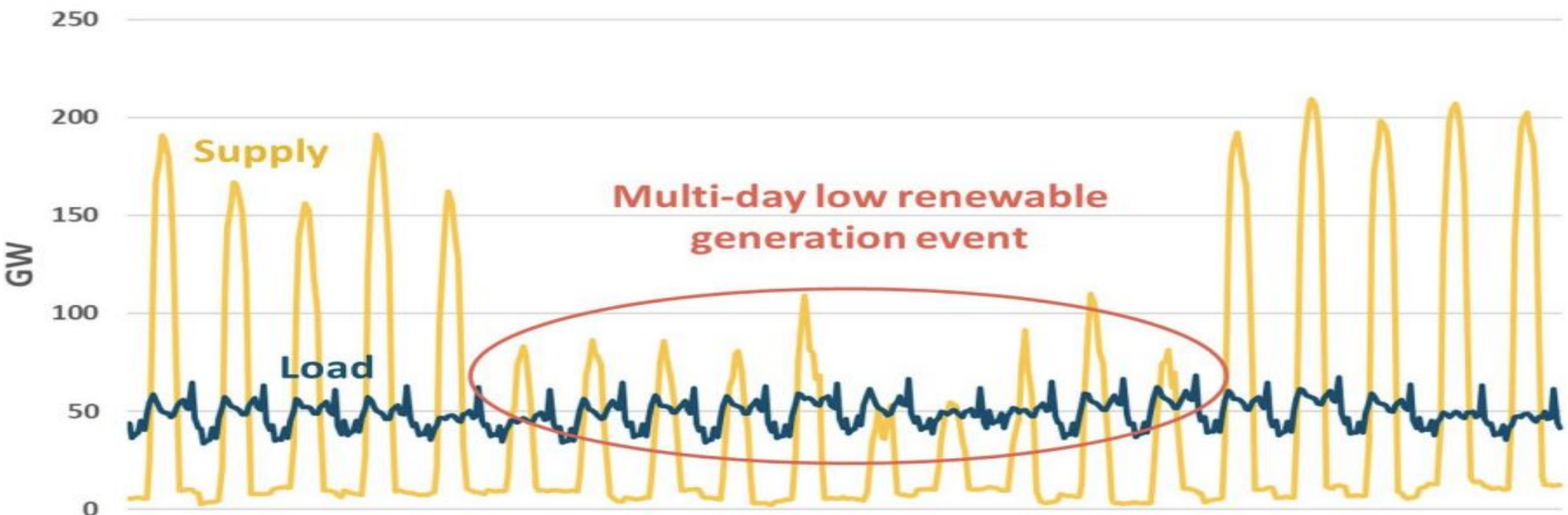
Source: E3, [Resource Adequacy in the Pacific Northwest](#)

## Upper Midwest Multi-Day Weather Event in Winter, 2019



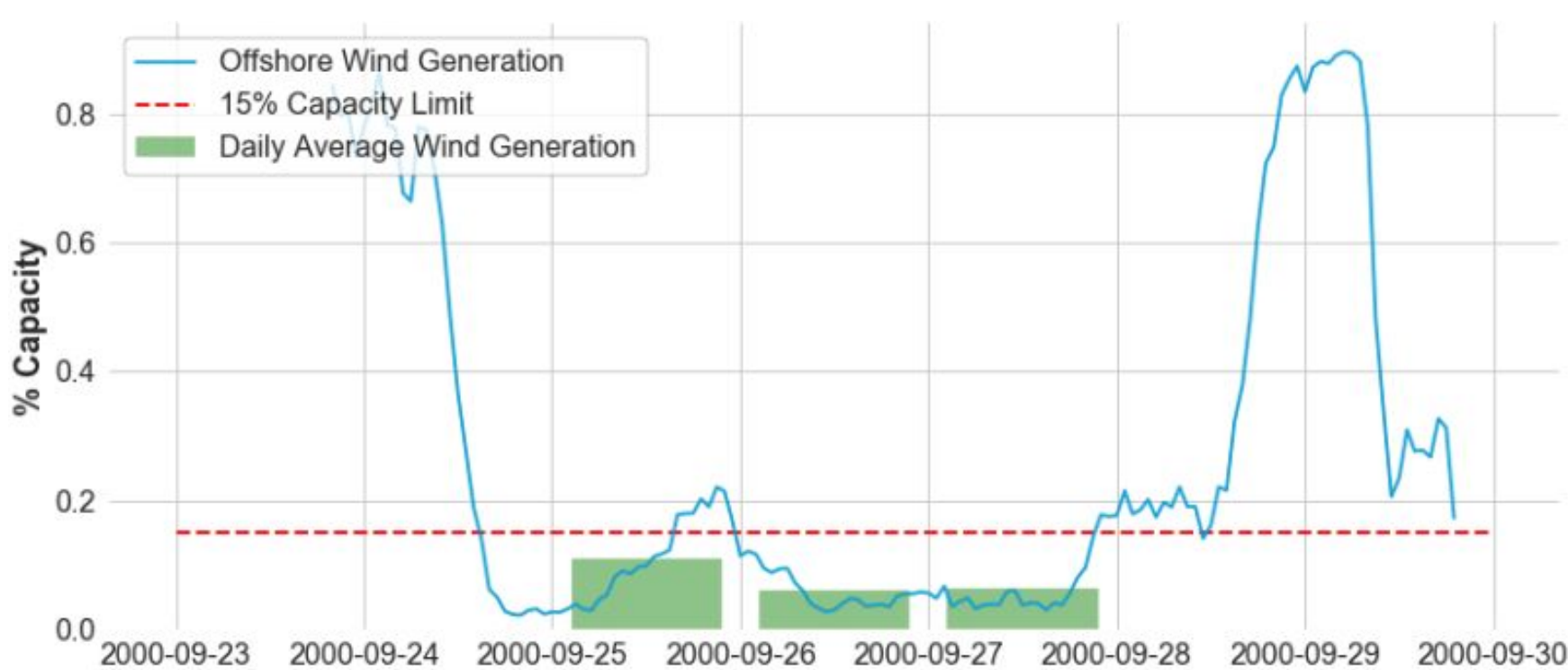
Source: [Xcel Energy](#) 2020-2034 Upper Midwest Resource Plan, May 20, 2019 Workshop

## California Multi-Day Weather Event in Winter, 2050



Source: E3: [Long-Run Resource Adequacy Under Deep Decarbonization](#)

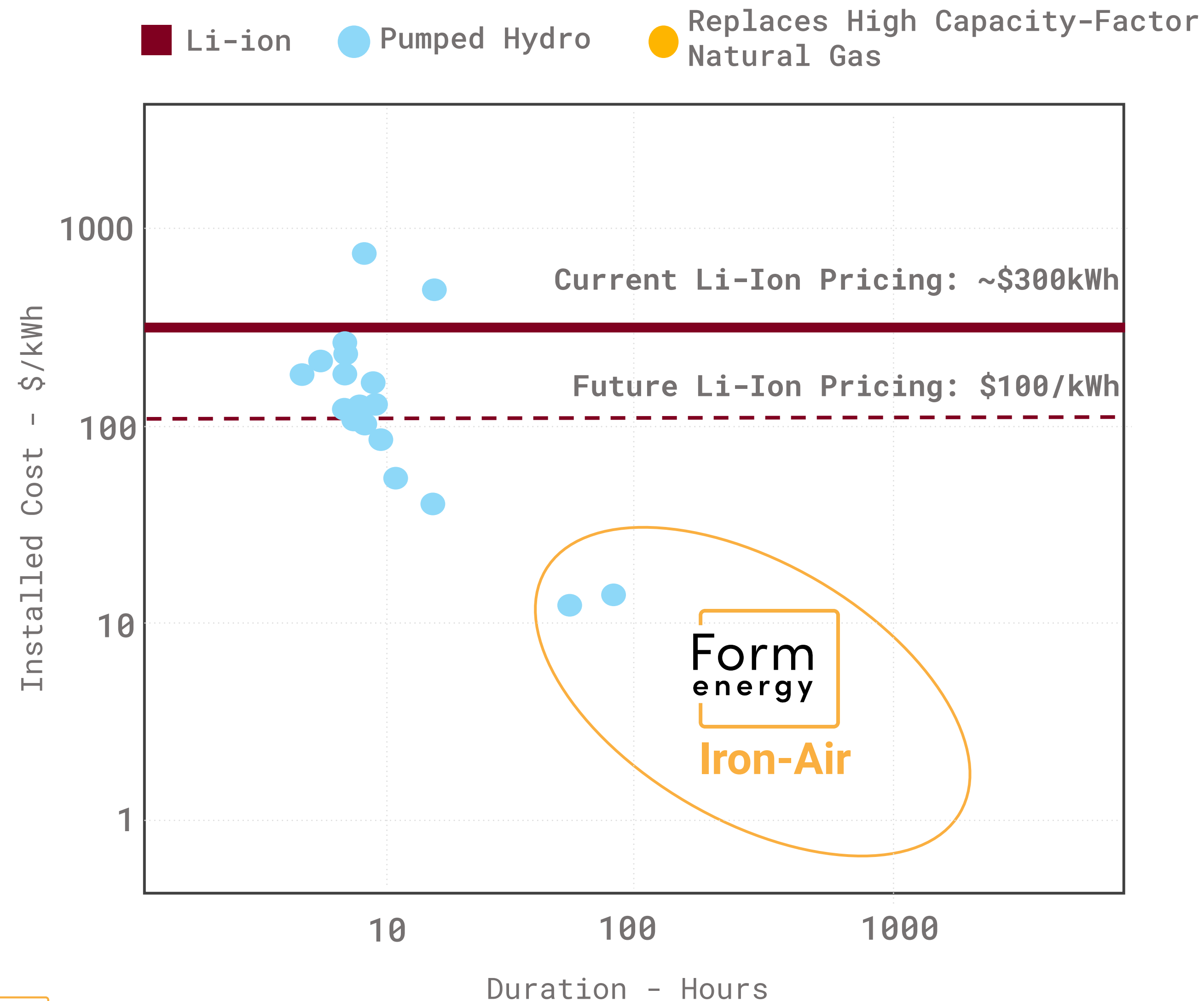
## New England Multi-day offshore wind lull, 2000



Source: [DNV-GL](#) Analysis of Stochastic Dataset for ISO-NE



# Our target: 10x lower cost and longer duration than lithium-ion

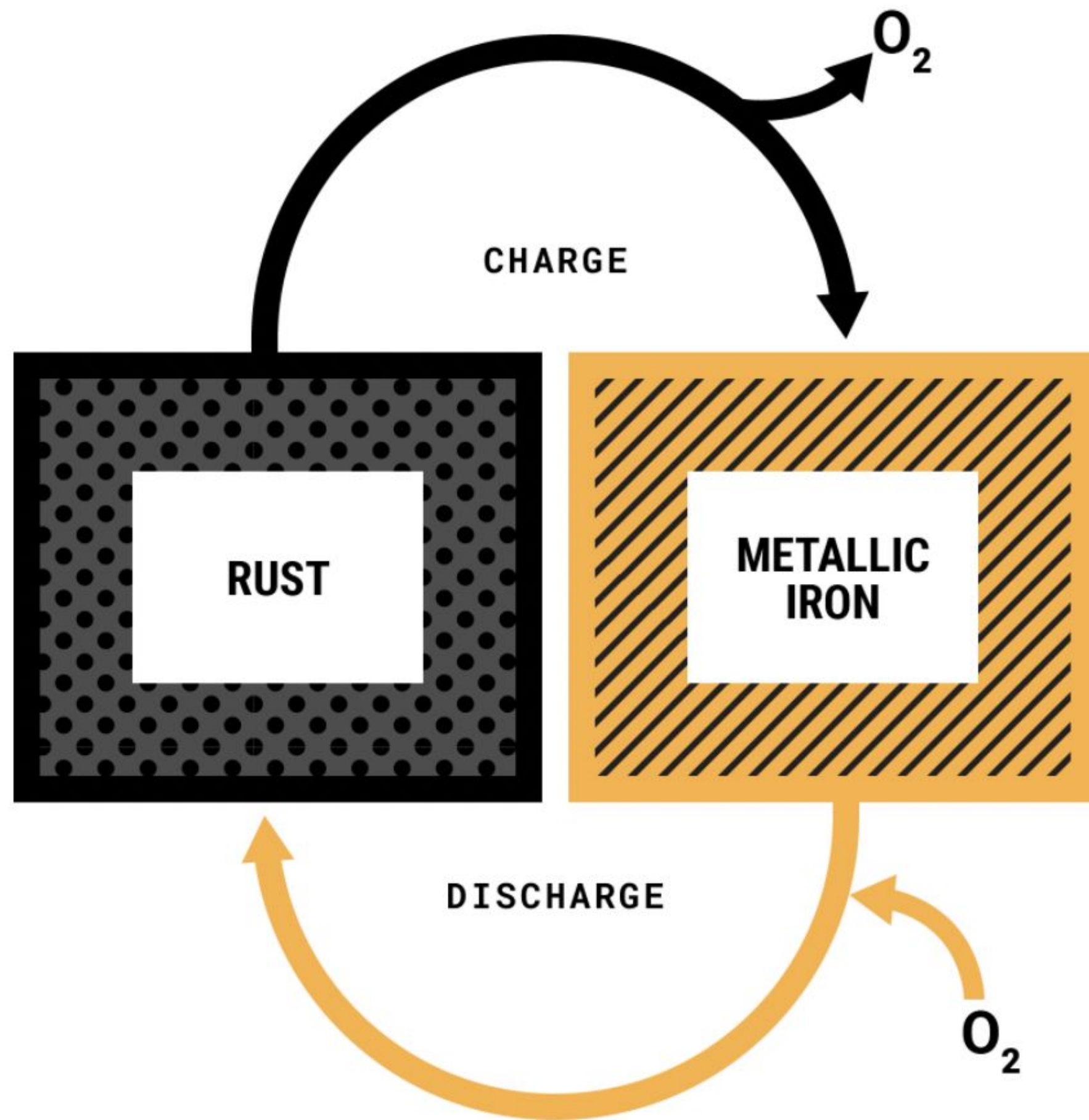


- **New storage solutions must be 10x longer duration and 10X cheaper than lithium ion** to enable renewables to replace gas and coal
- Pumped hydro is longest duration/lowest cost today



# Rechargeable iron-air is the best technology for multi-day storage

## Reversible Rust Battery



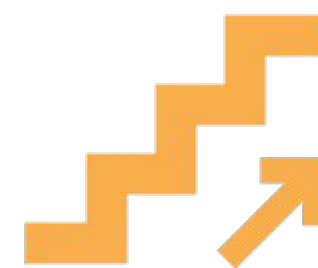
### COST

Lowest cost rechargeable battery chemistry.  
Less than 1/10th the cost of lithium-ion batteries



### SAFETY

Non-flammable aqueous electrolyte. No risk of thermal runaway. No heavy metals.



### SCALE

Uses materials available at the global scale needed for a zero carbon economy. High recyclability.



### RELIABLE

100+ hr duration required to make wind, water and solar reliable year round, anywhere in the world.



# Our rechargeable, static iron-air battery leverages globally abundant materials and off-the-shelf components

## SYSTEM BUILDING BLOCKS

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- **Iron Anode:**

- Highly abundant, very low cost metal, non-toxic
- Abundant local supply

- **Air Electrodes:**

- Commercially proven air electrodes
- Readily scalable production

- **Water-Based Electrolyte:**

- High pH (similar to AA batteries)
- Non-flammable, no heavy metals

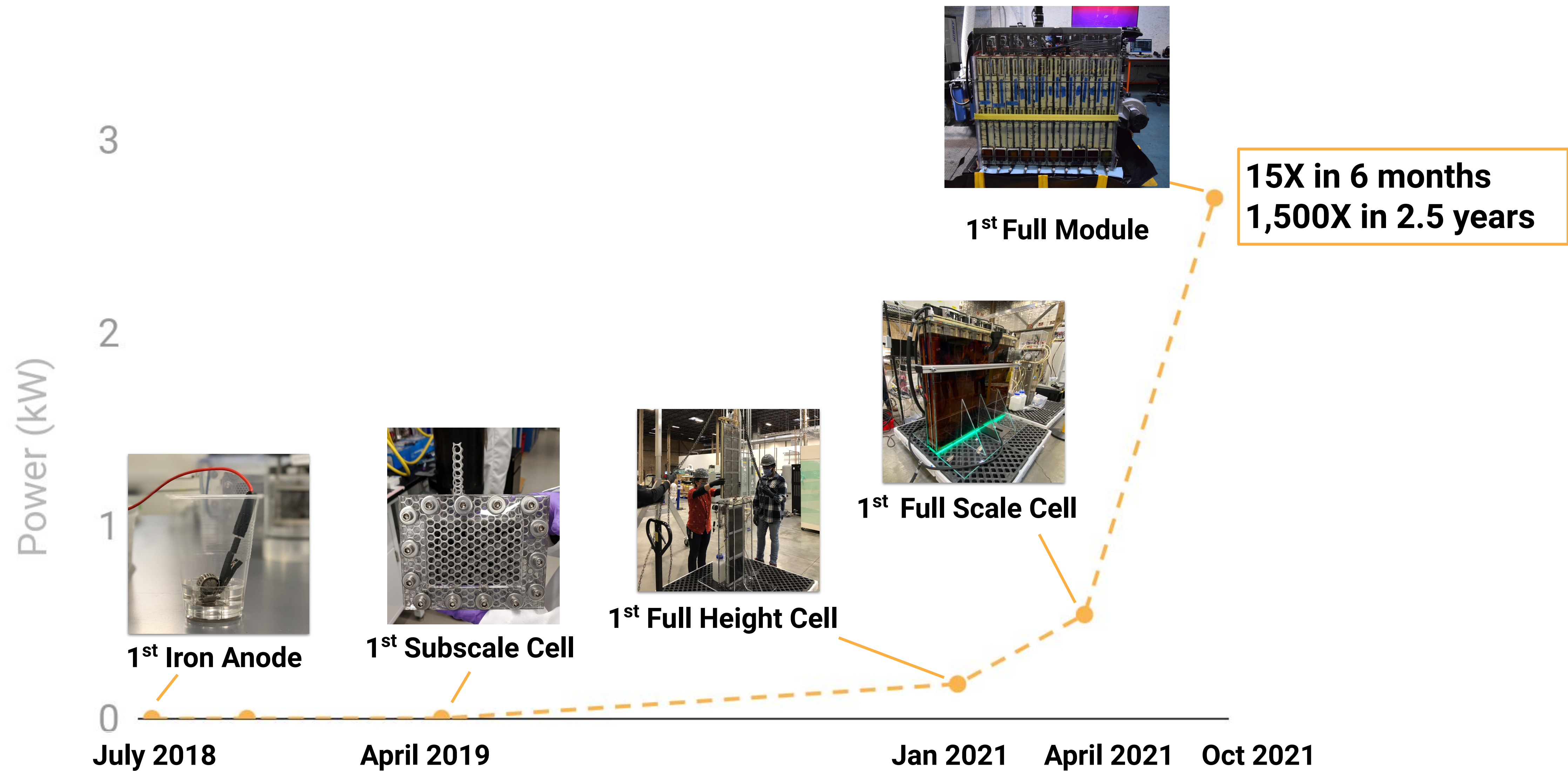
- **Balance-of-system:**

- Off-the-shelf water distribution, HVAC, & air handling system components
- Standard utility-grade inverter





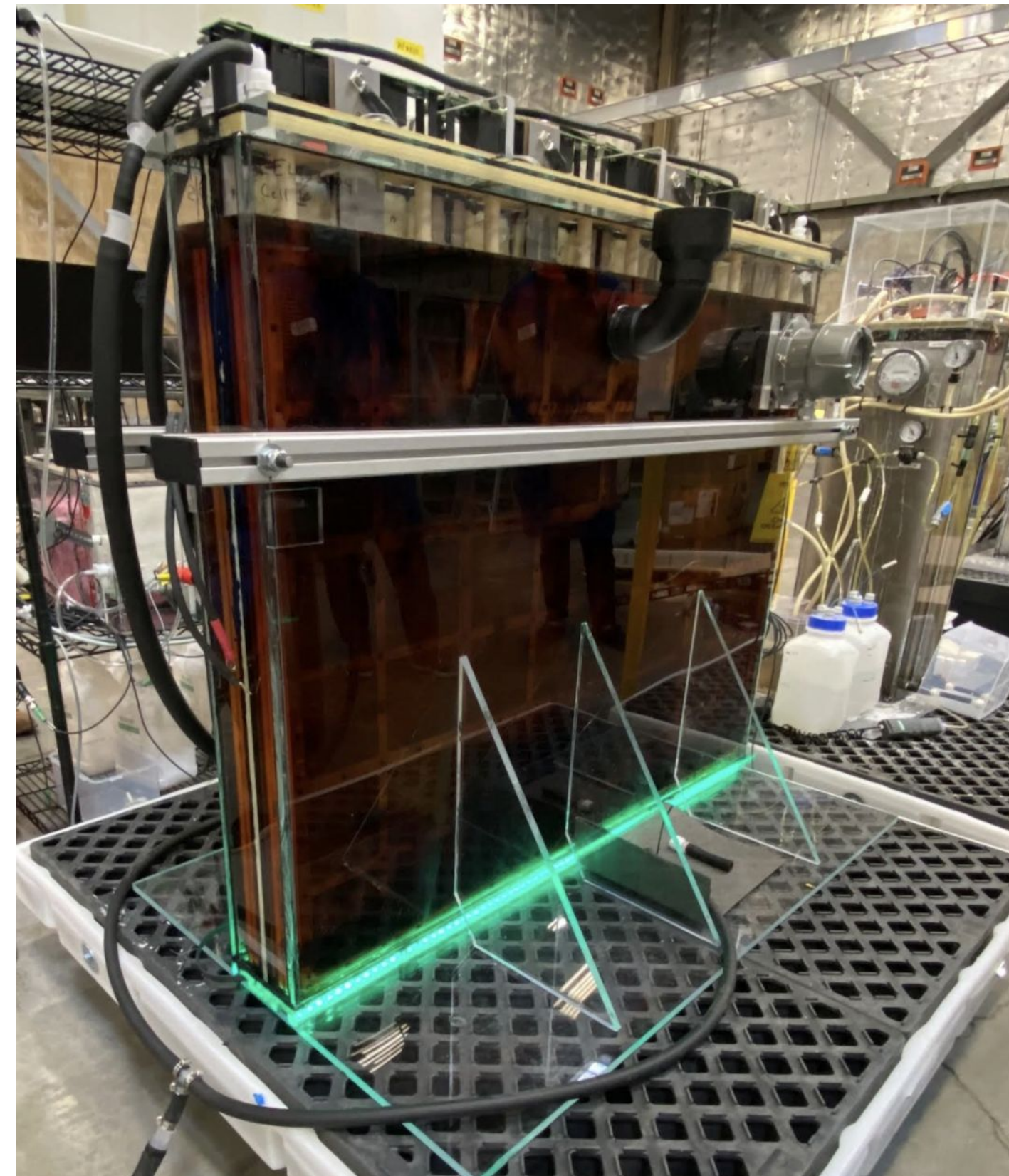
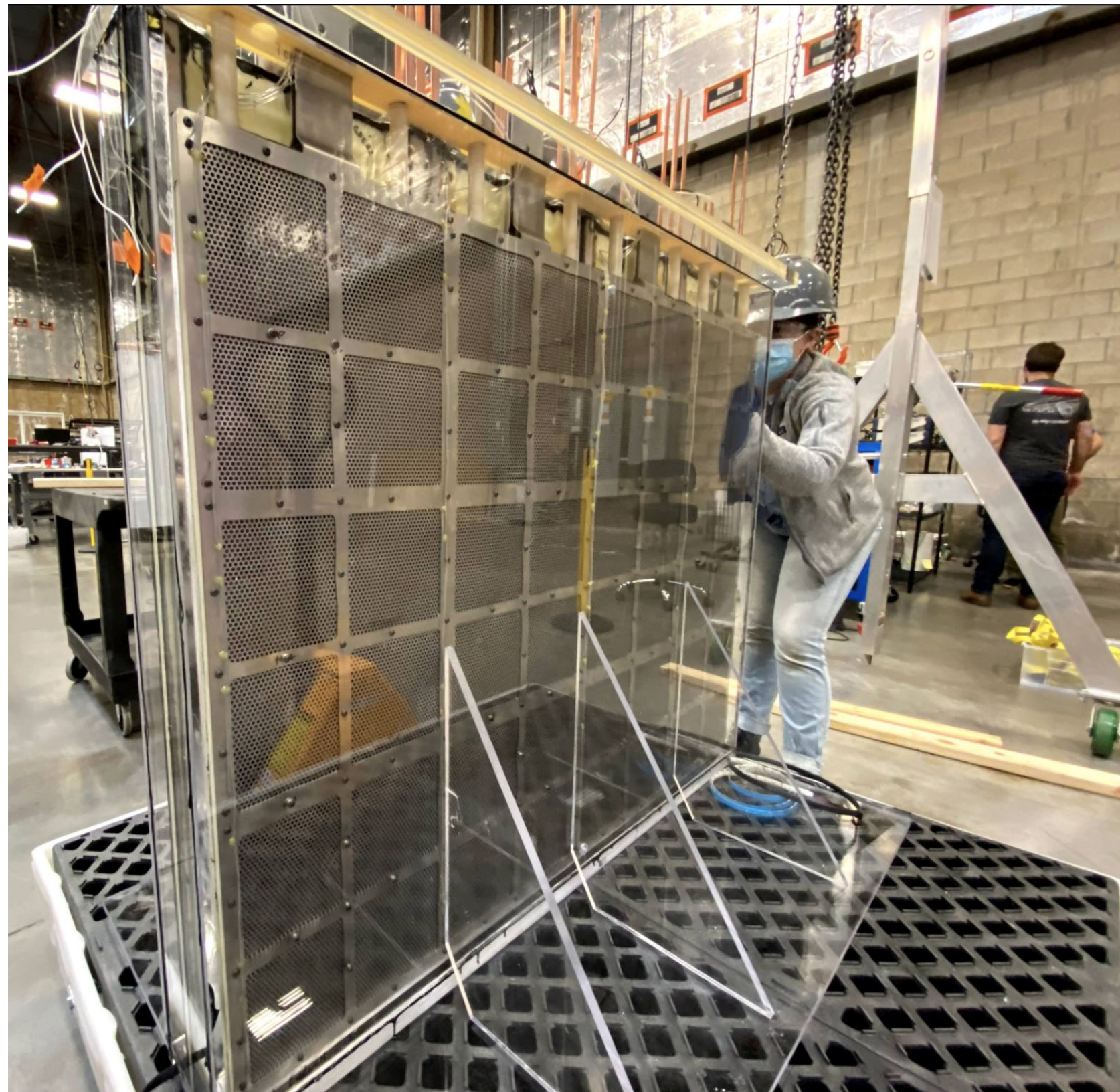
# Rapid scale





# Form Energy's cells are the largest battery cells in the world

~1 meter





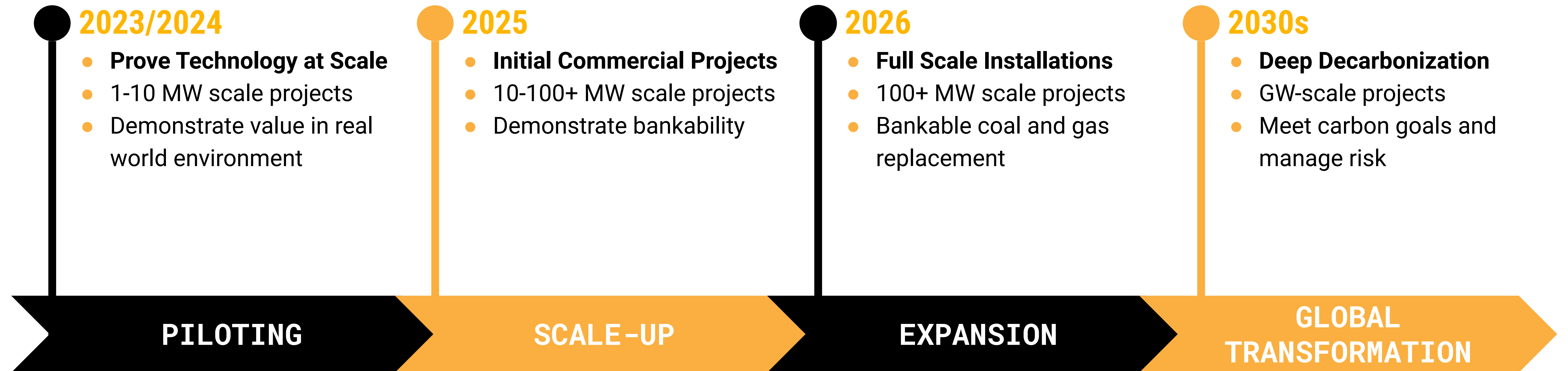
# First pilot project is contracted



- **Partner:** Great River Energy
- **Location:** Cambridge, Minnesota
- **Size:** 1 Megawatt, 150 Megawatt-hours
- **Online Date:** 2023



# Form Energy's path to transform the global grid



30 years after commercial availability, global lithium-ion manufacturing capacity was 500 GWh/yr in 2020. Form Energy will exceed that scale before 2030.



# Multi-day storage fills three key grid needs

## Firmed, 24/7 Renewables

- Provide guaranteed capacity year-round
- Shape renewable output to meet any load profile
- Lower market exposure

## Reliable Capacity Over Multiple Days

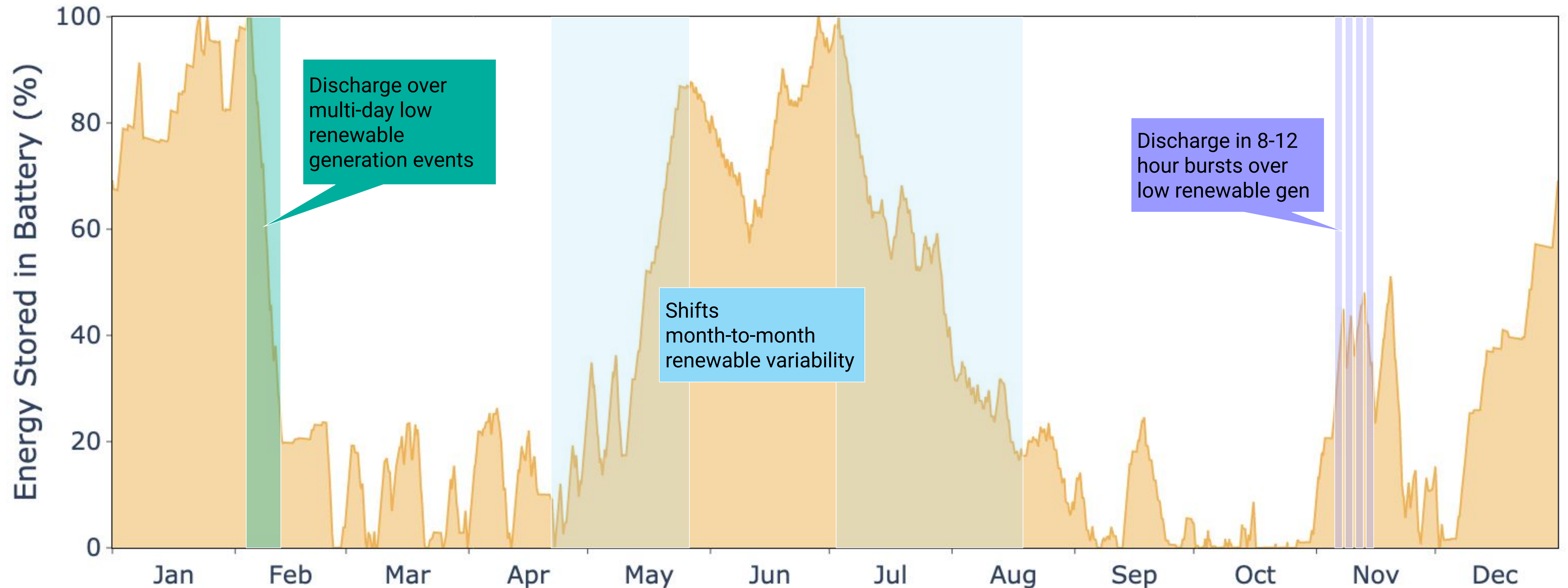
- Replace legacy fossil units with a clean alternative
- Lower costs by avoiding exposure to high risk events
- Fewer loss of load events

## Transmission Optimization

- Reduce renewable curtailment and congestion
- Increase the value of existing transmission
- Lower overall system costs



# Multi-Day Storage operates year-round to balance **seasonal, multi-day, and intra-day** variability in renewables



●  
**Multi-Day**

●  
**Seasonal Up**  
(net charge with excess renewables)

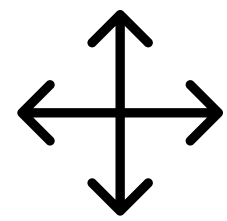
●  
**Seasonal Down**  
(net discharge during peak load season)

●  
**Intra-Day**



# Formware™ is the software platform for a deep renewables world

## Inputs



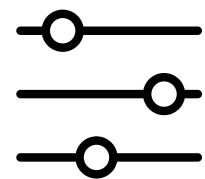
### Project-Specific Constraints

Site capacity, target availability, ...



### Sophisticated Storage Models

\$/kWh, \$/kW, RTE, ...



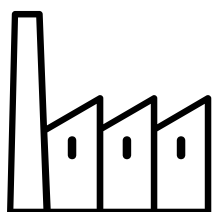
### Market Conditions

PPA price, capacity prices, energy and ancillary prices, RPS, ...



### Grid Data

Transmission limits, load forecasts, retirements, ...

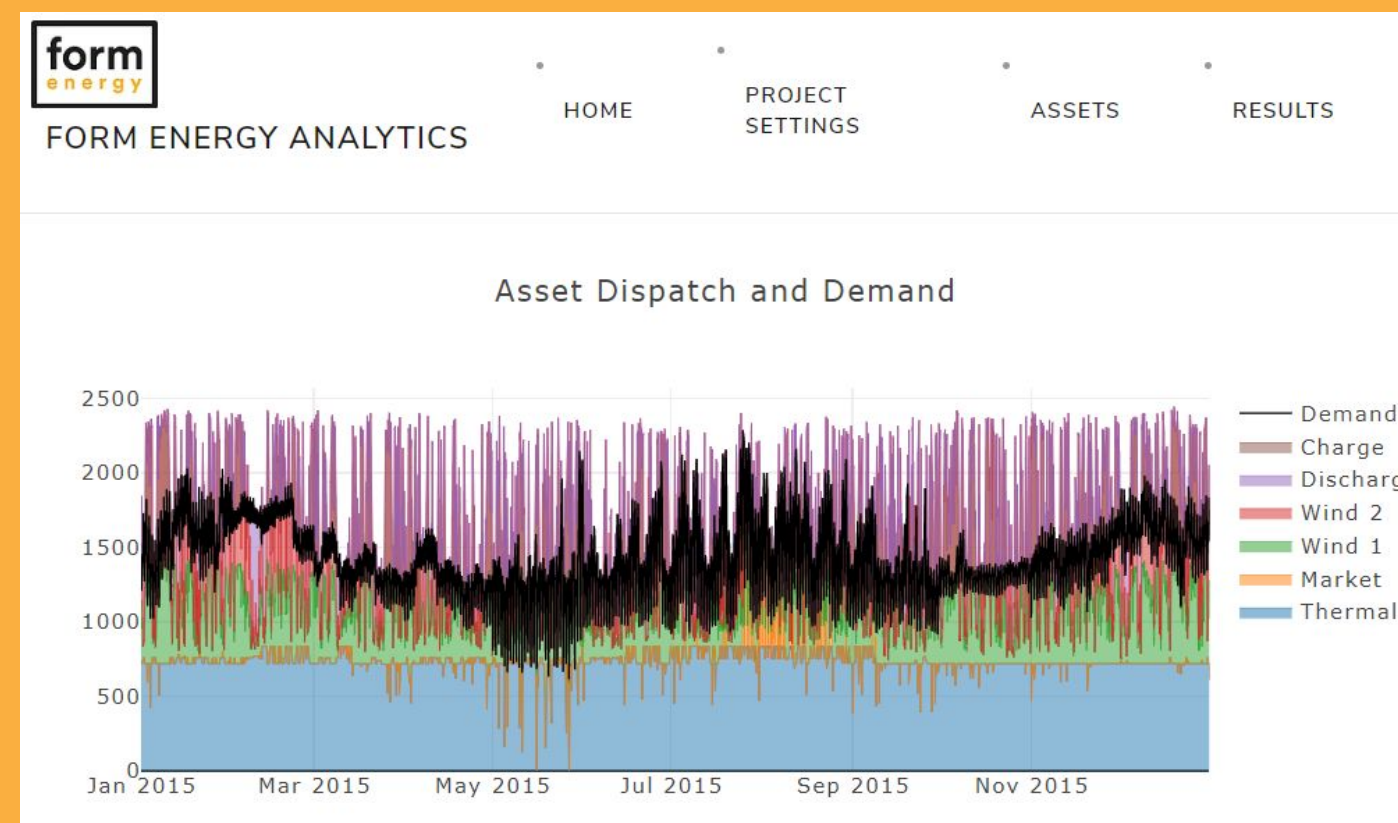


### Generator Data

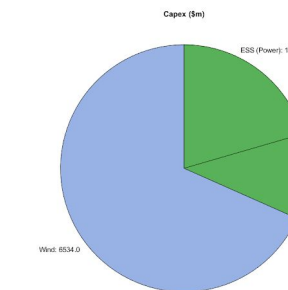
Capex, opex, start costs, heat-rates, fuel costs, solar & wind resource, ...

## Formware™ Software

- 8760+ model captures price and resource volatility
- Multi-scenario optimization validates solution across range of conditions
- Customizable model allows Form to deliver bespoke analyses on-demand

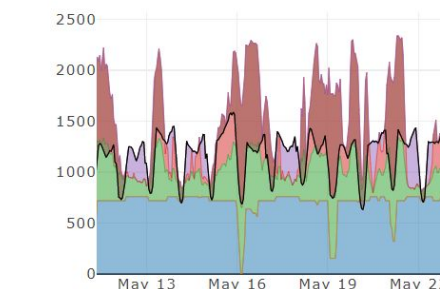


## Outputs



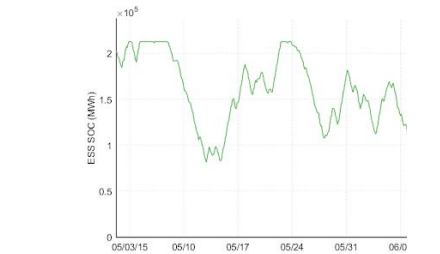
### Recommended Energy Asset Sizing

Power, energy capacity



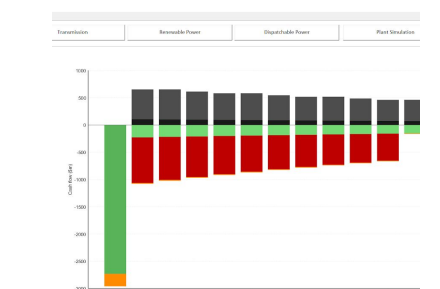
### Hourly Operational Profiles

8760+ by energy asset



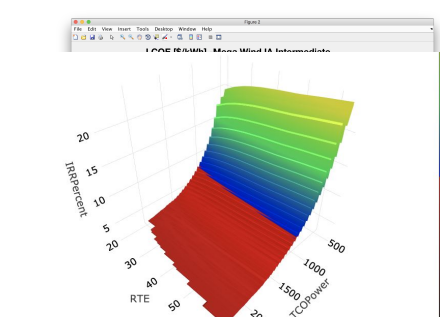
### Storage "Duty Profile"

Cycles/yr, peak power



### Project Financials

LCOE, FCF, IRR



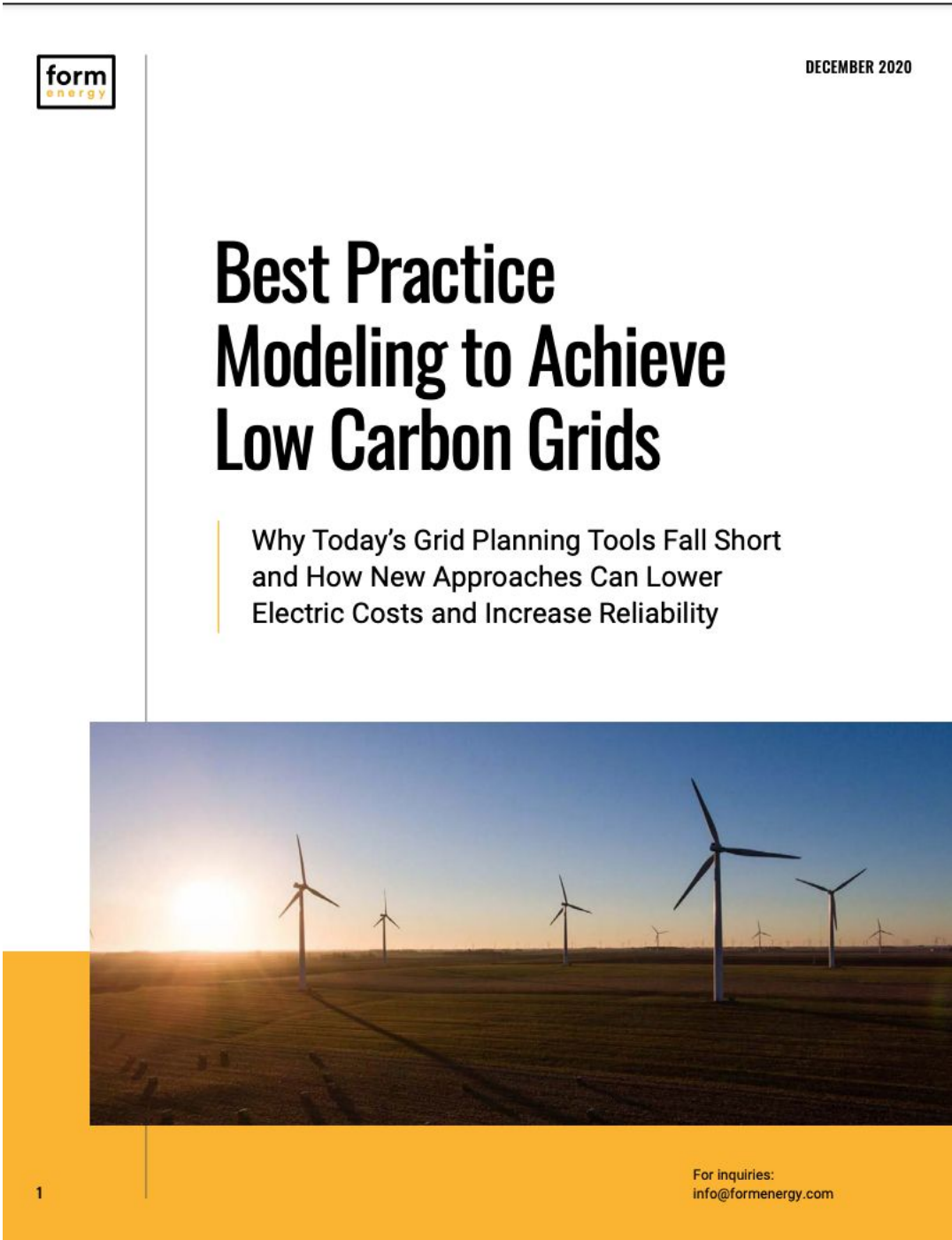
### Sensitivity Analysis

Risks and trade-offs from input uncertainties

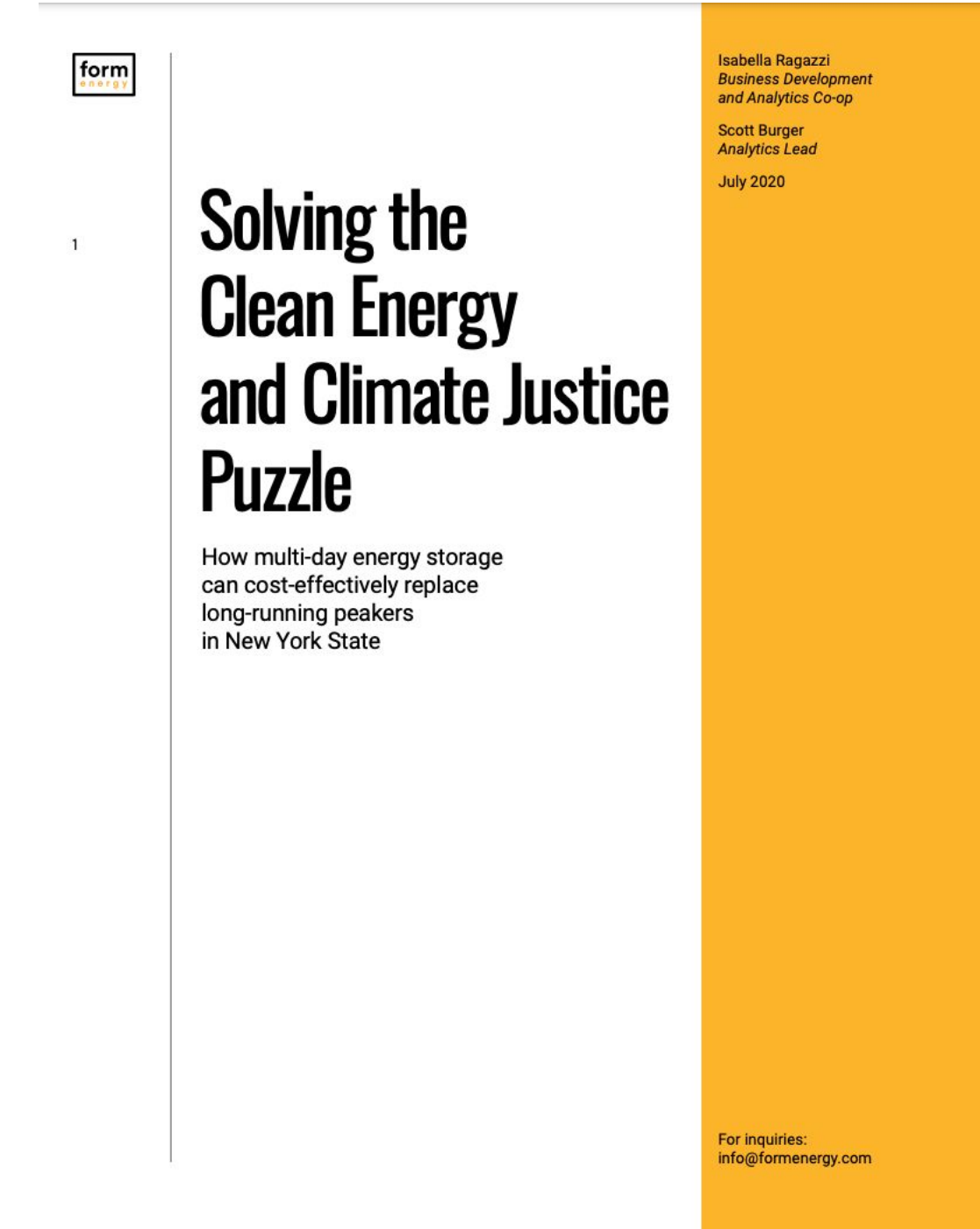


# Resources about Multi-Day Storage Applications and Value

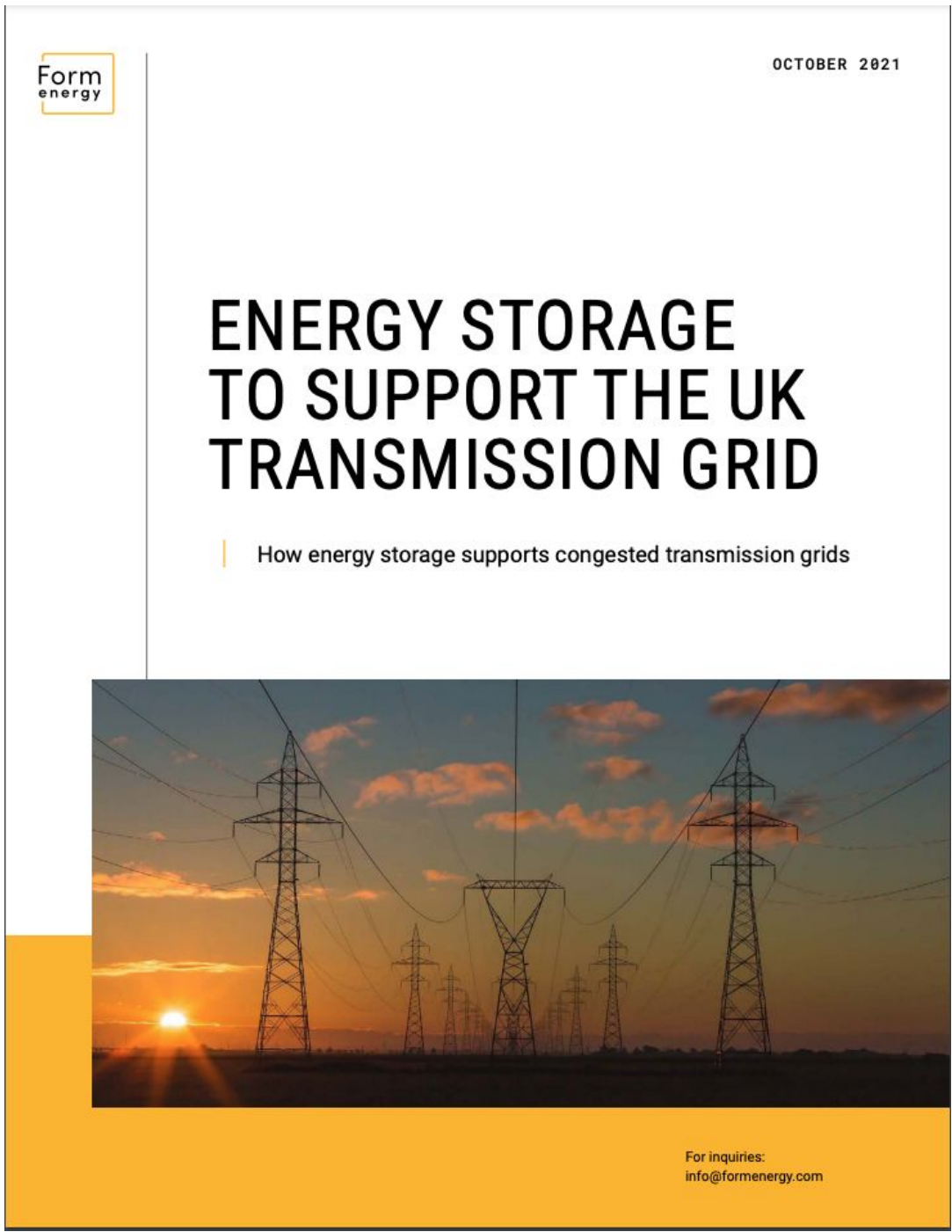
## Best Practice Modeling for Low Carbon Grids



## How Storage Can Replace Long-Running Peakers



## Transmission Enhancing Value of Storage



## Upcoming: Long-Duration Storage Study in CA

### **CEC EPC-19-056** **Assessing the Value of Long Duration Storage** Data & Scenario Selection Public Workshop

June 30, 2021





# Thank You!